2-28-00

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PATENT
Docket No. AIBT-9901

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of
Inventor(s): **Jiong Chen and Peiching Ling**

WARNING: Patent must be applied for in the name(s) of all the actual inventor(s). 37 CFR 1.41(a) and 1.53(b).

For (title): **APPARATUS AND METHOD FOR REDUCING ENERGY CONTAMINATION OF LOW ENERGY ION BEAM**

1. Type of Application

This new application is a(n) (check one applicable item below):

X Original
_ Design
_ Plant

WARNING: Do not use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. 371(c)(4) unless the International Application is being filed as a divisional, continuation or continuation-in part Application.

NOTE: If one of the following 3 items apply then complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED.

_ Divisional
_ Continuation
_ Continuation-in-part (CIP)

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this New Application Transmittal and the documents referred to as enclosed therein are being deposited with the United States Postal Service on this date February 24, 2000 in an envelope as "Express Mail Post Office to Addressee" Mailing Label Number EK481985649US addressed to the : Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Ching-lu Lin
(Type or print name of person mailing paper)

Ching-lu Lin

(Signature of person mailing paper)

NOTE: Each paper or fee referred to as enclosed herein has the number of the "Express Mail" mailing label placed thereon to mailing. 37 CFR 1.10(b).

2. Benefit of Prior U.S. Application(s) (35 USC 120)

NOTE: If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., then check the following item and complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

__ The new application being transmitted claims the benefit of prior U.S. application(s) and enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

3. Papers Enclosed Which Are Required For Filing Date Under 37 CFR 1.53(b) (Regular) or CFR 1.153 (Design) Application

__11__ Pages of specification
__6__ Pages of claims
__1__ Pages of Abstract
__4__ Pages of Drawings
  __X__ formal
  __ informal

WARNING: DO NOT submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted the Office. **Only one copy is required or desired.** Comments on proposed new 37 CFR 1.84. Notice of March 9, 1988 (1990 O.G. 57-62).

NOTE: "Identify indicia such as the serial number, group and unit, title of the invention, attorney's docket number, inventor's name, number of sheets, etc., not to exceed 2 3/4 inches (7.0 cm.) in which may be placed in a centered location between the side edges within three fourths inch (19.1 mm.) of the top edge. Either this marking technique on the front of the drawing is acceptable." Proposed 37 CFR 1.84 (1). Notice of March 9, 1988 (1090 O.G. 57-62)

4. Additional papers enclosed

_ Preliminary amendment
_ Information Disclosure Statement
_ Form PTO-1449
_ Citations
_ Declaration of Biological Deposit
_ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
_ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
_ Special Comments
_ Other

5. Declaration or oath

X Enclosed

executed by (*check* ***all*** *applicable boxes*)

X inventor(s).

_ legal representative of inventor(s) . 37 CFR 1.42 or 1.43

_ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached

_ this is the petition required by 37 CFR 1.47 and the statement required by 37 CFR 1.47 is also attached. *See item 13 below for fee.*

_ Not Enclosed.

WARNING: Where the filing is a completion in the U.S. of an International Application but where a declaration is not available or where the completion of the U.S. application contains subject matter in addition to the International Application the application may be treated as a continuation or continuation-in-part as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.

_ Application is made by a person authorized under 37 CFR 1.41 (c) on behalf of *all* the above named inventor(s). The declaration or oath, along with the surcharge required by 37 CFR 1.16 (e) can be filed subsequently.

NOTE: It is important that **all** the correct inventor(s) are named for filing under 37 CFR 1.41 (c) and 1.53 (b).

6. Inventorship Statement

WARNING: If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the **last** claimed invention was made, should be submitted.

The inventorship for all the claims in this application are:

X The same

or

_ Are not the same. An explanation, including the ownership of the various claims at the time the **last** claimed invention was made.

_ is submitted

_ will be submitted.

7. Language

NOTE: An application including a signed oath or declaration may be filed in a language other than English. A verified English translation of the non-English language application and the processing fee of $30.00 required by 37 CFR 1.17(k) is required to be filed with the application or within such time as may be set by the Office. 37 CFR 1.5(d).

NOTE: A non-English oath or declaration in the form provided or approved by the PTO need not be translated. 37 CFR 1.69(b).

X English

_ non-English

_ the attached translation is a verified translation. 37 CFR 1.52(d).

8. **Assignment**

X An assignment of the invention to **Advanced Ion Beam Technology, Inc.**

X is attached

_ will follow

NOTE: "If an assignment is submitted with a new application, send two separate letters-one for the application and one for the assignment" Notice of May 4, 1990.

9. **Certified Copy**

Certified cop(ies) of application(s)

(country) (appl.no.) (filed)

from which priority is claimed

_ **is (are) attached . A separate "ASSIGNMENT COVER LETTER ACCOMPANYING NEW PATENT APPLICATION" is also attached**

_ **will follow.**

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37CFR 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35USC120 is itself entitled to priority from a prior foreign application then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

10 Fee Calculation (37 CFR 1.16)

A X Regular application

CLAIMS AS FILED

Number filed		Number Extra		Rate	Basic Fee $690.00
Total Claims 37 CFR 1.16(c)	20-20 =	0	x	$18.00	0.00
Independent Claims (37CFR 1.16(b))	2 -3 =	0	x	$ 78.00	0.00
Multiple dependent claim(s), if any (37 CFR 1.16(d))				$260.00	0.00

_ **Amendment Cancelling extra claims enclosed.**

_ **Amendment deleting multiple-dependencies enclosed.**

_ **Fee for extra claims is not being paid at this time.**

note: If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37CFR1.16(d).

Filing fee calculation $ 690.00

B. _ **Design application**
($310.00 - 37 CFR 1.16(f))

Filing fee calculation $__________

C _ **Plant application**
($510.00 - 37 CFR 1.16(g))

Filing fee calculation $__________

11. Small Entity Statement(s)

_X Verified Statement(s) that his is a filing by a small entity under 37 CFR 1.9 and 1.27 is (are) attached.

Filing Fee Calculation (50% of **A**, **B**, or **C** above) $____**345.00**

NOTE: any excess of the full fee paid will be refunded if a verified statement and a refund request are filed within 2 months of the date of timely payment of a full fee. 37 CFR 1.28(a).

12. Request for International-Type Search (37 CFR 1.104(d)) (*complete, if applicable*)

_ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. Fee Payment Being Made At This Time

_ Not Enclosed

_ No filing fee is to paid at this time. (*This and the surcharge required by 37 CFR 1.16(e) can be paid subsequently.*)

X Enclosed

X basic filing fee $__________**345.00**

X recording assignment
($40.00; 37 CFR 1.21(h)) $__________**40.00**

_petition fee for filing by other than all the inventors or person on behalf of the inventor where inventor refused to sign or cannot be reached.
($120.00; 37 CFR 1.47 and 1.17(h)) $______________

_ for processing an application with a specification in a non-English language. ($300.00; 37 CFR 1.52(d) and 1.17(k)) $______________

_ processing and retention fee
($130.00; 37 CFR 1.53(d) and 1.21(l))

_ fee for international-type search report
($40.00; 37 CFR 1.21(e)) $______________

NOTE: 37 CFR 1.21(l) establishes a fee for processing and retaining any application which is abandoned for failing to complete the application pursuant to 37 CFR 1.53(d) and this, as well as the changes to 37 CFR 1.53 and 1.78, indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid or the processing and retention fee of 1.21(l) must be paid within 1 year from notification under 53(d).

Total fees enclosed $ __________**385.00**

14. **Method of Payment of Fees**

X Check in the amount of $ 385.00

_ Charge Account No. in the amount of $________. A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner the it is clear for which purpose the fees are paid. 37 CFR 1.22(b).

15. **Authorization to Charge Additional Fees**

WARNING: if no fees are to be paid on filing the following items should **not** be completed.

WARNING: Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.

X The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 12-0005.

X 37 CFR 1.16(a), (f) or (g) (filing fees)

X 37 CFR 1.16(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 CFR 1.16(d)) it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

_ 37 CFR 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later then the filing date of the application)

_ 37 CFR 1.17 (application processing fees)

WARNING: While 37 CFR 1.17(a),(b) (c) and (d) deal with extensions of time under 1.136(a) this authorization should be made only with the knowledge that: "Submission of the appropriate extension fee under 37 C.F.R. 1.136(a) is to avail unless a request or petition for extension is filed." (Emphasis added). Notice of November 5, 1985 (1060 O.G. 27)

_ 37 CFR 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 CFR 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 CFR 1.311(b).

NOTE: 37 CFR 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application...prior to paying, issue fee". From the wording of 37 CFR 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

16. **Instructions As to Overpayment**

_ credit Account No.

X refund

Reg. No.33,948

SIGNATURE OF ATTORNEY

Bo-In Lin

Type or print name of attorney

Tel. No. (415) 949-0418

P.O. Address : **13445 Mandoli Drive, Los Altos Hills, CA 94022**

__ Incorporation by reference of added pages

Check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR A NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED

_ Plus Added Pages For New Application Transmittal Where Benefit Of Prior U.S. Application(s) Claimed

Number of pages added ______________

_ Plus Added Pages For Papers Referred To In Item 4 Above

Number of pages added ______________

_ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added ______________

X Statement Where No Further Pages Added

(If no further pages form a part of this Transmittal then end this Transmittal with this page and check the following item)

X This transmittal ends with this page

AIBT-9901

In the United States Patent and Trademark Office

First/Sole Applicant: Jiong Chen Joint/Second Applicant: Peiching Ling

TITLE: APPARATUS AND METHOD FOR REDUCING ENERGY CONTAMINATION OF LOW ENERGY ION BEAM

Small Entity Declaration - Small Business Concern

I hereby declare that I am an
[ ] the owner of the small business concern identified below:
[x] an officer of the small business concern empowered to act on behalf of

the concern identified below:

NAME OF CONCERN: Advanced Ion Beam Technology, Inc.

ADDRESS OF CONCERN: 116 South Wolfe Road, Sunnyvale, CA 94086

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the above entitled invention of the above applicants and the specification filed herewith.

I acknowledge a duty to file, in the above application for patent notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Signature or Officer of Small Business Concern

10/1/99
Date

Jiong Chen, Vice President of Technology
Name and Title of Officer
116 South Wolfe Road, Sunnyvale, CA 94086
Address of Officer

APPARATUS AND METHOD FOR REDUCING ENERGY CONTAMINATION OF LOW ENERGY ION BEAMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention disclosed herein relates generally to ion implantation methods employed in the manufacturing process of semiconductor devices. Specifically, this invention relates to an improved implantation process for manufacturing semiconductor devices that include shallow p-type or n-type regions by delivering ultra low energy (0.2 to 2.0 keV) ion beams to targets by employing an improved ion implantation method.

2. Description of the Prior Art

As semiconductor device dimensions continue to shrink, source-drain junction depths are reduced accordingly. Shallow junction formation is, however, fast becoming one of the major limiting factors in the modern semiconductor fabrication process. To those skilled in the art of making modern Ultra Large-Scale Integrated (ULSI) circuits conventional ion implantation methods do not provide production worthy solutions to the semiconductor industry.

A technology roadmap presented by Saito in IIT'98 [International Conference on Ion Implantation Technology, Kyoto, Japan, 1998] indicates that sub-keV implantation energy is required for the 0.15 μm and below technology nodes. For example, 0.5 keV boron ions are used for 0.13 μm devices and 0.2 keV for 0.1 μm devices. Conventional implantation systems are unable to provide production worthy beam currents at energies below 2 keV because of space-charge beam blow up (i.e. divergence) associated with low energy beams.

One method that is used to achieve high beam currents at energies below 2 keV involves extraction of ions at higher energies than that desired, followed by a mass analysis, and then the ions are decelerated just before they reach the targets [J.G. England, et al., US Patent 5969366: *Ion Implanter With Post Mass Selection Deceleration*, 1999]. One problem with this method, however, is that neutralization of ions prior to deceleration may occur in the region between the mass analyzer and the deceleration electrodes when the ions interact with residual gases in the beam line. These resulting neutrals will not be decelerated by the deceleration electric fields and may therefore reach the wafers at higher than desired energies. This effect is known as energy contamination and leads to a deeper than desired dopant depth profile. Energy contamination is only tolerable to a level of ~ 0.1%, depending on the energy of the neutral fraction, to provide a sufficient margin against shifts in device performance [L. Rubin, and W. Morris, "Effects of Beam Energy Purity on Junction Depths in Sub-micron Devices", Proceedings of the International Conference on Ion Implantation Technology, 1996, p96].

Reducing the beamline pressure can reduce the energy contamination but this approach requires the chamber pressures to be kept very low (5.0E-7 torr). This level of vacuum is, however, very difficult to be maintained under normal operating conditions due to the out-gassing of the photo-resist coating of patterned devices as well as the contribution from feed gases. Another issue is the variation in the level of contamination. Pressure fluctuations during the implant can cause across wafer effects. Day-to-day changes in residual vacuum or photo-resist quality may cause batch-to-batch effects. There is a potential for the loss of wafers, potentially worth millions of dollars, due to undetected vacuum problems. Methods have been invented to detect energy contamination due to high chamber pressure during ion beam deceleration [B. Adibi, US Patent 5883391: Ion Implantation Apparatus And A Method Of Monitoring High Energy Neutral Contamination In An Ion Implantation Process, 1999].

Fig. 1 is a functional block diagram for a conventional low energy ion implantation system used for generating a low energy beam 10 from an ion source 15 for carrying out a low energy ion implant on a target wafer 20. The ion beam 10 generated from the ion source 15 is mass analyzed by a magnetic analyzer 25 and travels along a curved trajectory that makes a nearly ninety-degree turn. The positively charged particles are decelerated by applying a negative voltage 30 along the ion beam path 10 for reducing the implant energy when the ion beam 10 passes through the deceleration optics 35 to reach the target wafer 20. The drawback of this system is the presence of the neutral particles, which are not decelerated by the negative voltage 30. These neutral particles will bombard the target wafer 20 at a higher energy than the decelerated charged particles and cause undesirable effects to the devices. The vacuum has to be maintained at a very high level within the sealed space by the beamline chamber 40 and the target chamber 50 to minimize the neutralization of the ion beam.

The use of plasma electron flood systems and out-gassing of photoresist wafers are two reasons why it is impractical to have a high vacuum in the chambers 40 and 50. To prevent beam blow-up after deceleration and wafer charging during implants, an electron flood source or a plasma flood source should be placed between the deceleration optics 35 and the target wafer 20. These flood sources usually require substantial gas flow, such as xenon or argon gas, for the best performance. The gas flow out of the flood source increases the gas pressure in chambers 40 and 50. Additionally, ion beam bombardment of the target wafer with patterned photoresist coating generates significant out-gassing that also contributes to an increase of the gas pressure in the chambers 40 and 50, particularly near the wafer.

For the above stated reasons, traditional techniques of ion implantation using conventional types of energy deceleration systems as described above do not provide a viable solution for the difficulties currently associated with the fabrication processes employing very low energy implantation. There is a pressing need in the art of IC device

fabrication for new systems and methods used for very low energy ion implantation. Specifically, for devices that require shallow p-type and n-type junctions, new methods and systems are required to resolve these difficulties and limitations with effective control over energy contamination of low energy beams.

Separating a decelerated ion beam from neutral particles by electrostatic field has been used in nuclear fusion technology [Hashimoto et al., US Patent 4480185: *Neutral Beam Injector,* 1984]. Similar concept of this technology can be applied to the ion implantation technology to solve energy contamination problem during ion beam deceleration.

SUMMARY OF THE PRESENT INVENTION

It is the object of the present invention to provide a new ion implant method for low energy implantation to form shallow p-type and n-type junctions in semiconductor devices. Specifically, it is the object of the present invention to present a new ion beam steering and deceleration method for decelerating a charged ion beam and for separating the neutralized particle beam from the ion beam. The neutralized beam, which propagates at a higher energy than the decelerated ion beam, is separated and stopped by a neutral-particle-stopping block before reaching the target wafer. In this way, energy contamination as a result of neutralized particles incident to the target with higher than desired energy is resolved.

An ion implantation method is disclosed in this invention that involves an ion beam deceleration optics that includes a beam deceleration means for decelerating the ion beam for producing a low energy ion beam. The beam deceleration optics further includes a beam steering means for generating an electrostatic field for steering the ion beam to a targeted ion-beam direction and separating neutralized particles from the ion beam by allowing the neutralized particles to transmit in a neutralized-particle direction slightly different from the

targeted ion-beam direction. The ion beam steering means further includes a beam stopper for blocking said neutralized particles from reaching said target of implantation that minimizes energy contamination from high energy neutralized particles.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a functional block diagram of a conventional ion implantation system.

Fig. 2 is a diagram of a new implantation system of this invention under normal operation without ion beam steering.

Fig. 3 is a diagram of a new implantation system of this invention with ion beam steering when the deceleration electrodes are used to steer the ion beam downward (a) or upward (b) to separate the neutral beam and the ion beam.

DETAILED DESCRIPTION OF THE METHOD

The present invention teaches a novel low-energy ion implant method involving the separation of the charged ion beam from the uncharged neutralized particles. Fig. 2 is a diagram of the current invention. The diagram of the ion beam implant system includes the ion source 105, the mass analyzer magnet assembly 125, beamline chamber 140, post analysis deceleration electrode assembly 135, plasma shower 145, and target chamber 150 for implanting a target wafer 120 with an ion beam 110. Under normal operation, the ion beam is mass-selected and decelerated by the decel electrode assembly 135, and is transported to the target wafer 120. The plasma shower 145 helps to reduce the space charge of the decelerated ion beam 110 and increase the beam transportation efficiency from the decel electrode assembly 135 to the wafer 120. As the ion beam 110 travels through the resolving chamber 140 some charged particles may be neutralized through the process of charge exchange with

residual gas in the beamline. The deceleration voltage will not decelerate these neutralized particles because they do not carry any charge. The speed and direction of the neutral particles are not affected by the electric field. When these neutral particles with higher energy reach the target wafer 120 together with the decelerated ion beam, they will cause energy contamination with deeper implant profile.

Separating the neutral particle beam and the ion beam to prevent the neutral beam from reaching the wafer is the most effective way to eliminate the energy contamination. In this invention, the beam is steered downward (Figure 3a) or upward (Figure 3b) in decel-mode by displacing one or several of the decel electrodes off the beam line symmetric axis on the dispersive plane defined by the mass analyzer magnet. The non-symmetric electric field bends the ion beam with an off-axis angle as a function of the decel electrode displacements and the decel electrode voltages. After passing through the decel electrode assembly 135, the path of the neutralized particles and the charged particles are therefore separated during deceleration and become two separate beams 110-1 and 110-2. The neutralized particle beam 110-1 travels along a straight line while the charged ion beam 110-2 is travels along a path with a slightly downward (or upward) angle, in a range of three to fifteen degrees, such that the beam is directed at the target wafer 120. Note that the angle can be different depending on a particular system configuration. A beam stopper 155 is employed in the path of the neutralized particle beam 110-1 to block the neutralized beam 110-1 from reaching the target wafer 120. The target wafer 120 is tilted with a small slant angle relative to the vertical axis such that the wafer normal is parallel to the incident ion beam 110-2. The wafer is also moved downward (or upward) from the normal implant position as shown in Fig.2 to a new position as shown in Fig.3a (or Fig.3b) to accept the steered ion beam.

The invention discloses an ion implantation method that requires the use of a target chamber for containing a target for implantation and an ion source chamber that includes an ion source with a mass analyzer for generating an ion beam with specific mass at original energy. The ion

source chamber further includes beam deceleration optics for decelerating the ion beam from the original energy to the desired final energy. The beam deceleration optics further includes an ion beam steering means for generating an electrostatic field. The electrostatic field is applied to steer the ions to the targeted ion-beam direction that is slightly different from the original ion beam direction. The targeted ion-beam direction has a small downward (or upward) angle, in a range from three to fifteen degrees, while the neutralized beam particles are unaffected by the deceleration and steering means and travel in the original beam direction. The target chamber containing the target for implantation is tilted backward (or forward), as shown in Fig.3a and 3b, at a small angle in a range from three to fifteen degrees toward the ion-source chamber whereby the target for implantation may be perpendicular to the ion beam. A beam stopper is provided in the neutralized beam path to prevent the neutralized beam from reaching the implant target in the target chamber. The energy contamination from high-energy neutral particles is therefore eliminated regardless how many neutral particles are created from ion beam interaction with the residual gas molecules. Low energy contamination of less than 0.1% can be achieved even low vacuum environment exists in the beamline. In a specific embodiment, the ion source chamber is provided with a vacuum in the range of 10^{-5} Torr and the ion beam may be decelerated to an energy level as low as 200 eV with a beam energy contamination of less than 0.1%.

The original beam is required to have small beam width for separating the decelerated and steered ion beam with the neutralized beam in a position not far from the deceleration region to significantly reduce energy contamination. Assume that the steering angle is θ_o, the beam width is w for both the neutralized beam and decelerated ion beam, and the travel distance for completely separating the neutralized beam and the steered ion beam is L. The steering angle θ_o should be maintained small, usually from three degrees to fifteen degrees, to minimize corresponding wafer position change and possible beam current loss. The travel distance L should be short to maximize beam current delivery to the wafer when space charge blow-up occurs for low energy and high

current beam. Since the relation among these parameters is approximately $w = L \tan\theta_o$, the beam width is required to be small, too. For instance, when θ_o is equal to 6 degrees and L equal 30cm, w will become 3.2cm.

Considering that large beam cross section is required to minimize space charge blow-up for low energy and high current beam, the beam height should be increased when the beam width is limited to be small. In other words, an ion beam with large aspect ratio (or large height-to-width ratio) is required in the deceleration and steering region for successfully separating the decelerated and steered ion beam from the neutralized beam, and transporting the production worthy low energy beam currents. An aspect ratio of 4 is considered to be the minimum requirement for separation of a low energy and high current ion beam from the corresponding neutralized beam. Since the beam width is usually larger than 2.5cm, the beam height would be at least 10cm. After the neutralized beam is separated from the decelerated ion beam, a beam stopper can be applied in the neutralized beam path to prevent the neutrals with higher energy from reaching the wafer and therefore minimize energy contamination.

For an ion source with a narrow extraction aperture, the aspect ratio of an ion beam usually decreases when the beam travels from the ion source/extraction region to the deceleration and steering region because the space charge blow-up is more severe in the dispersive plane than in the non-dispersive plane defined by the analyzer magnet. To obtain an ion beam with aspect ratio larger than 4 in the deceleration and steering region, the aspect ratio of the ion source extraction aperture should be several times larger than 4. We consider that the aspect ratio of the ion source extraction aperture is at least equal to 20 to provide high aspect ratio beams in the region of deceleration and steering for successful separation of the decelerated and steered ion beam and the neutralized beam.

According to Figs. 2 and 3, this invention discloses a method for performing an ion implantation. The method includes steps of a) providing a target chamber for containing a target for implantation and

an ion source chamber including an ion source for generating an ion beam; b) providing a beam deceleration optics that includes a beam deceleration means in the ion source chamber for decelerating the ion beam for producing a low energy ion beam; c) providing a beam steering means to the beam deceleration optics to separate neutralized particles out of the ion beam by keeping the neutralized particles propagating in a neutralized-particle direction slightly different from a steered targeted ion-beam direction; and d) employing the ion-beam deceleration optics for transmitting the ion beam along the targeted ion-beam direction to the target for implantation and for blocking the neutralized particles from reaching the target for implantation. In a preferred embodiment, the method further includes a step of e) providing an analyzer magnet to the ion source chamber for mass filtering. In a preferred embodiment, the step of employing the beam deceleration means further includes a step of providing a deceleration electric-field means for generating a deceleration electric-field for decelerating the ion beam for producing a low energy ion beam. In a preferred embodiment, the step of employing the ion beam steering means for generating an electrostatic field for keeping the neutralized particle to transmit along a trajectory different than the ion beam carrying electric charges comprising a step of steering the ion beam to transmit in a targeted ion-beam direction slightly different from the neutralized-particle direction. In a preferred embodiment, the step of employing an ion-beam deceleration optics further includes a step of employing a neutralized beam blocking means for blocking the neutralized particle from reaching the target of implantation in the target chamber. In a preferred embodiment, the step of providing an ion source in an ion source chamber is a step of providing an ion source for generating a positive charged ion beam. And, the step of employing the beam deceleration means includes the step of employing a deceleration electric-field means for generating a negative electric-field for decelerating the ion beam for producing a low energy ion beam. In a preferred embodiment, the step of employing the ion beam steering means comprising a step of steering the ion beam carrying electric charges to transmit in the targeted ion-beam direction at a small deflected angle. In a preferred embodiment, the step of employing the ion beam steering

means to steer the ion beam carrying electric charges to transmit in the targeted ion-beam direction comprising a step of steering the ion beam at a small deflected angle in a range of three to fifteen degrees relative to the horizontal axis. In a preferred embodiment, the step of providing the ion source in the ion source chamber comprising a step of providing the ion source chamber and the target chamber with a vacuum in the range of 10^{-5} Torr. And, the step of employing the ion beam deceleration means comprising a step of decelerating the ion beam to an energy level as low as about 200 eV with an energy contamination of less than about 0.1%.

In essence, this invention discloses a method for generating an implantation ion beam from an ion source projecting a plurality of ions. The method includes steps of a) employing a beam deceleration means for decelerating the ions projected from the ion source; b) employing a beam steering means for generating an electrostatic field for separating a plurality of neutralized particles from the ion ions by keeping the neutralized particles propagating in a neutralized-particle direction slightly different from a targeted ion-beam direction of the ions. In a preferred embodiment, the method further includes a step c) arranging a wafer implant position corresponding to the targeted ion-beam direction for accepting the ions projected thereto. In a preferred embodiment, the step of employing a means for transmitting the ions to a target of implantation comprising a step of employing a means for blocking the neutralized particles from reaching the target of implantation. In a preferred embodiment, the step of separating the neutralized particles from the ions comprising a step of providing a charged particle deflection means for deflecting the trajectory of the ions at a small angle from the trajectory of the neutralized particles. In a preferred embodiment, the method further comprising a step of configuring the ion beam deceleration means for decelerating and processing the ions into an ion beam having a large beam-height to beam-width ratio. In another preferred embodiment, the method further comprising a step of providing a beam block for blocking the neutralized particles propagating in the neutralized-particle direction. In a preferred embodiment, the method further includes a step of projecting the ions in forming the implantation ion beam with high beam current and low and a ratio of a beam height to a beam width equal or larger

than 20. In another preferred embodiment, the step of forming the implantation ion beam having a ratio of a beam height to a height to a beam width equal or larger than 20 comprising a step of providing an extraction aperture for the ion source with an aspect ratio equal or larger than 20. In another preferred embodiment, the step of configuring the ion beam deceleration means for decelerating and processing the ions into an ion beam having a large beam-height to beam-width ratio comprising a step of processing the ions into an ion beam having a beam-height to beam-width ratio equal or greater than 4. And, the step of processing the ions into an ion beam having a beam-height to beam-width ratio equal or greater than 4 comprising a step of providing an aperture of a deceleration and steering optics having a beam-height to beam-width ratio equal or greater than 4. In a preferred embodiment, the step of providing a charged particle deflection means for deflecting the trajectory of the ions at a small angle from the trajectory of the neutralized particles comprising a step of deflecting the trajectory of the ions at an angle in the range of three to fifteen degrees.

Therefore, the present invention provides a new low energy implant method used to form shallow p-type and n-type junctions in semiconductor devices. Specifically, a new ion beam deceleration method is disclosed for decelerating a charged ion beam and for separating a neutralized beam from the ion beam. The neutral beam is composed of neutral particles propagating at energies higher than the desired energy. The neutral beam is separated and stopped by a neutral-particle-stopping block so that it is unable to reach the target wafer. The problem of energy contamination in very low energy implants using decel-mode is thus resolved using this invention.

Although the present invention has been described in terms of the presently preferred embodiment, it is to be understood that such disclosure is not to be interpreted as limiting. Various alterations and modifications will no doubt become apparent to those skilled in the art after reading the above disclosure. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

CLAIMS

We claim:

1 A method for performing an ion implantation comprising:

providing a target chamber for containing a target for implantation and an ion source chamber including an ion source for generating an ion beam;

providing a beam deceleration optics that includes a beam deceleration means in said ion source chamber for decelerating said ion beam for producing a low energy ion beam;

providing a beam steering means to said beam deceleration optics to separate neutralized particles out of said ion beam by keeping said neutralized particles propagating in a neutralized-particle direction slightly different from a steered targeted ion-beam direction; and

employing said ion-beam deceleration optics for transmitting said ion beam along said targeted ion-beam direction to said target for implantation and for blocking said neutralized particles from reaching said target for implantation.

2. The method of performing an ion implantation of claim 1 wherein:

providing an analyzer magnet to said ion source chamber for mass filtering.

3. The method of performing an ion implantation of claim 1 wherein:

said step of employing said beam deceleration means further includes a step of providing a deceleration electric-field means for generating a deceleration electric-field for decelerating said ion beam for producing a low energy ion beam.

4. The method of performing an ion implantation of claim 1 wherein:

said step of employing said ion beam steering means for generating an electrostatic field for keeping said neutralized particle to transmit along a trajectory different than said ion beam carrying electric charges comprising a step of steering said ion beam to transmit in a targeted ion-beam direction slightly different from said neutralized-particle direction.

5. The method of performing an ion implantation of claim 1 wherein:

said step of employing an ion-beam deceleration optics further includes a step of employing a neutralized beam blocking means for blocking said neutralized particle from reaching said target of implantation in said target chamber.

6. The method of performing an ion implantation of claim 1 wherein:

said step of providing an ion source in an ion source chamber is a step of providing an ion source for generating a positive charged ion beam; and

said step of employing said beam deceleration means includes the step of employing a deceleration electric-field means for generating a negative electric-field for decelerating said ion beam for producing a low energy ion beam.

7. The method of performing an ion implantation of claim 1 wherein:

said step of employing said ion beam steering means comprising a step of steering said ion beam carrying electric charges to transmit in said targeted ion-beam direction at a small deflected angle.

8. The method of performing an ion implantation of claim 7 wherein:

said step of employing said ion beam steering means to steer said ion beam carrying electric charges to transmit in said targeted ion-beam direction comprising a step of steering said ion beam at a small deflected angle in a range of three to fifteen degrees relative to the horizontal axis.

9. The method of performing an ion implantation of claim 1 wherein:

said step of providing said ion source in said ion source chamber comprising a step of providing said ion source chamber and said target chamber with a vacuum in the range of 10^{-5} Torr; and

said step of employing said ion beam deceleration means comprising a step of decelerating said ion beam to an energy level as low as about 200 eV with an energy contamination of less than about 0.1%.

10. A method for generating an implantation ion beam from an ion source projecting a plurality of ions comprising:

employing a beam deceleration means for decelerating said ions projected from said ion source;

employing a beam steering means for generating an electrostatic field for separating a plurality of neutralized particles from said ion ions by keeping said neutralized particles propagating in a neutralized-particle direction slightly different from a targeted ion-beam direction of said ions.

11. A method of claim 10 further comprising:

arranging a wafer implant position corresponding to said targeted ion-beam direction for accepting said ions projected thereto.

12. The method of claim 10 further comprising:

said step of transmitting said ions to a target of implantation further comprising a step of employing a means for blocking said neutralized particles from reaching said target of implantation.

13. The method of claim 10 wherein:

said step of separating said neutralized particles from said ions comprising a step of providing a charged particle deflection means for deflecting said trajectory of said ions at a small angle from said trajectory of said neutralized particles.

14. The method of claim 10 further comprising:

configuring said ion beam deceleration means for decelerating and processing said ions into an ion beam having a large beam-height to beam-width ratio.

15. The method of claim 10 further comprising:

providing a beam block for blocking said neutralized particles propagating in said neutralized-particle direction.

16. The method of claim 10 further comprising:

projecting said ions in forming said implantation ion beam with high beam current and low and a ratio of a beam height to a beam width equal or larger than 20.

17. The method of claim 16 wherein:

said step of forming said implantation ion beam having a ratio of a beam height to a height to a beam width equal or larger than 20 comprising a step of providing an extraction aperture for said ion source with an aspect ratio equal or larger than 20.

18. The method of claim 10 wherein:

said step of configuring said ion beam deceleration means for decelerating and processing said ions into an ion beam having a large beam-height to beam-width ratio comprising a step of processing said ions into an ion beam having a beam-height to beam-width ratio equal or greater than 4.

19. The method of claim 18 wherein:

said step of processing said ions into an ion beam having a beam-height to beam-width ratio equal or greater than 4 comprising a step of providing an aperture of a deceleration and steering optics having a beam-height to beam-width ratio equal or greater than 4.

20. The method of claim 13 wherein:

said step of providing a charged particle deflection means for deflecting said trajectory of said ions at a small angle from said trajectory of said neutralized particles comprising a step of deflecting said trajectory of said ions at an angle in the range of three to fifteen degrees.

ABSTRACT

An ion implantation method for reducing energy contamination in low energy beams is disclosed in this invention. The ion implantation method requires the use of a target chamber for containing a target for implantation in vacuum and an ion source chamber with an ion source for generating an ion beam. A means for conducting a mass analysis of the ion beam, such as an analyzer magnet, is also needed. The ion source chamber includes a beam deceleration optics that includes a beam deceleration means for decelerating the ion beam for producing a low energy ion beam. The beam deceleration optics further includes a beam steering means for generating an electrostatic field for steering the ion beam to a targeted ion-beam direction and separating neutralized particles from the ion beam by allowing the neutralized particles to transmit in a neutralized-particle direction slightly different from the targeted ion-beam direction. The ion beam steering means further includes a beam stopper for blocking said neutralized particles from reaching said target of implantation that minimizes energy contamination from high energy neutralized particles.

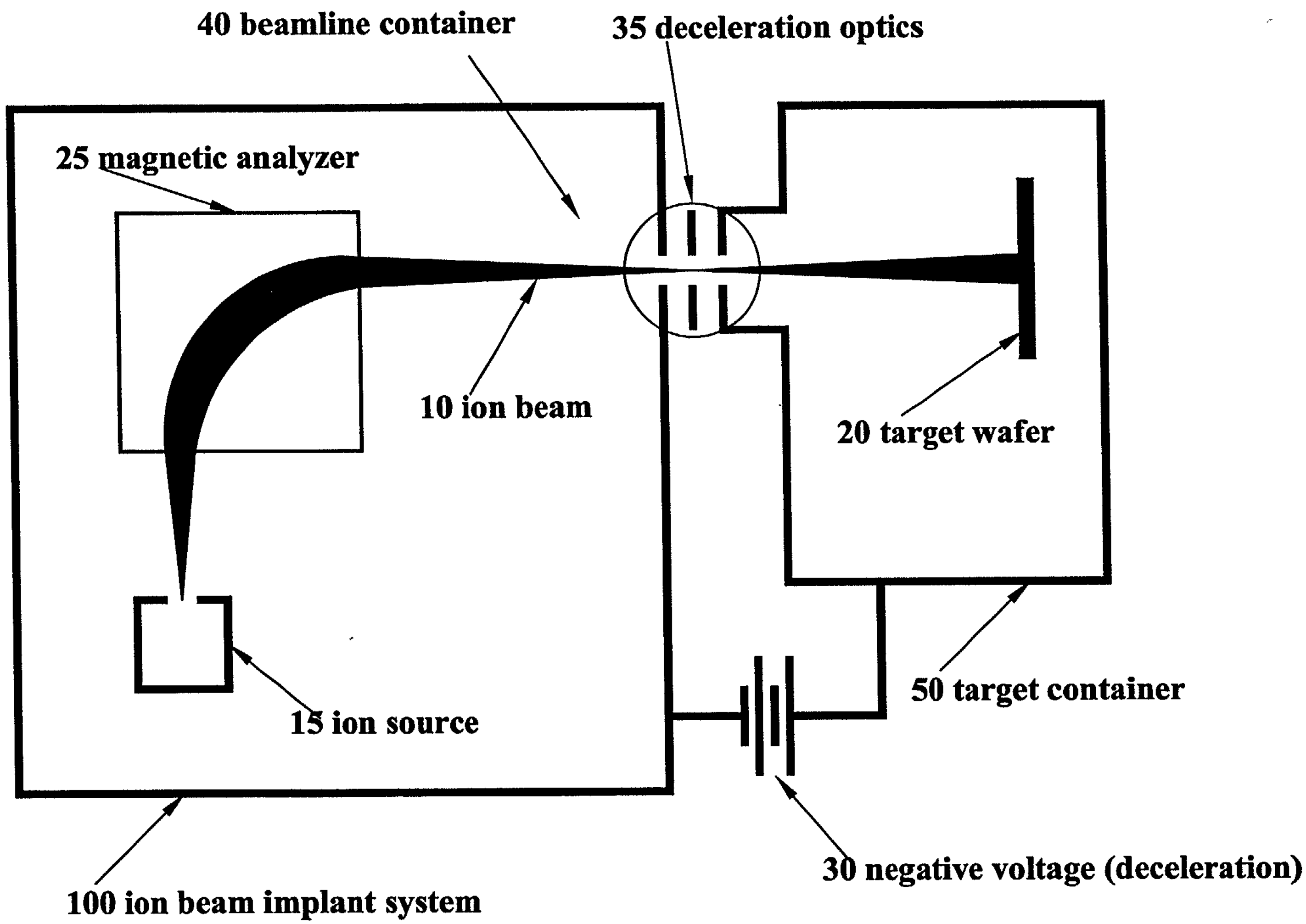
40 beamline container
35 deceleration optics
25 magnetic analyzer
10 ion beam
20 target wafer
15 ion source
50 target container
100 ion beam implant system
30 negative voltage (deceleration)

Figure 1

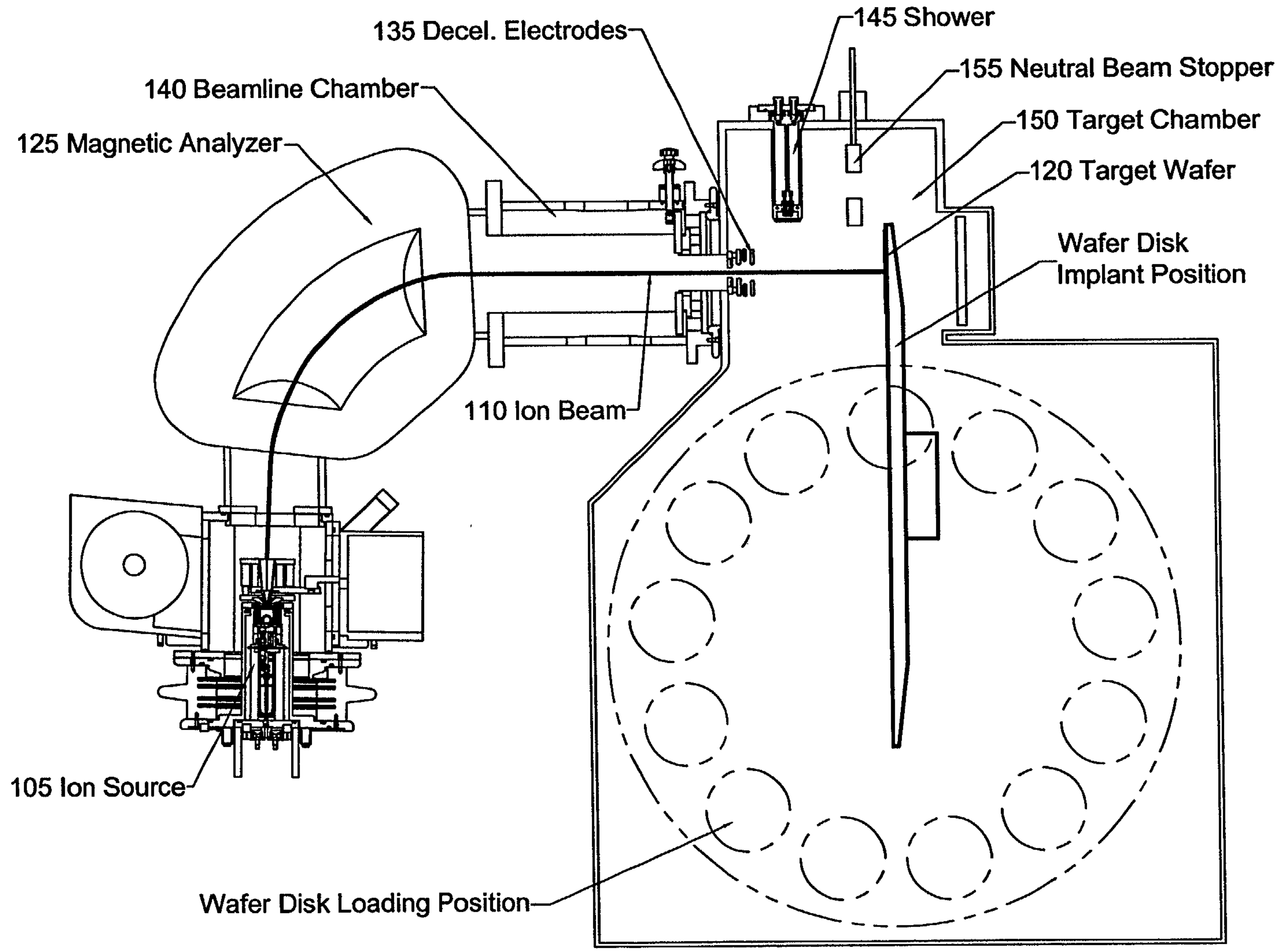
145 Shower
135 Decel. Electrodes
155 Neutral Beam Stopper
140 Beamline Chamber
150 Target Chamber
125 Magnetic Analyzer
120 Target Wafer
Wafer Disk
Implant Position
110 Ion Beam
105 Ion Source
Wafer Disk Loading Position

Figure 2

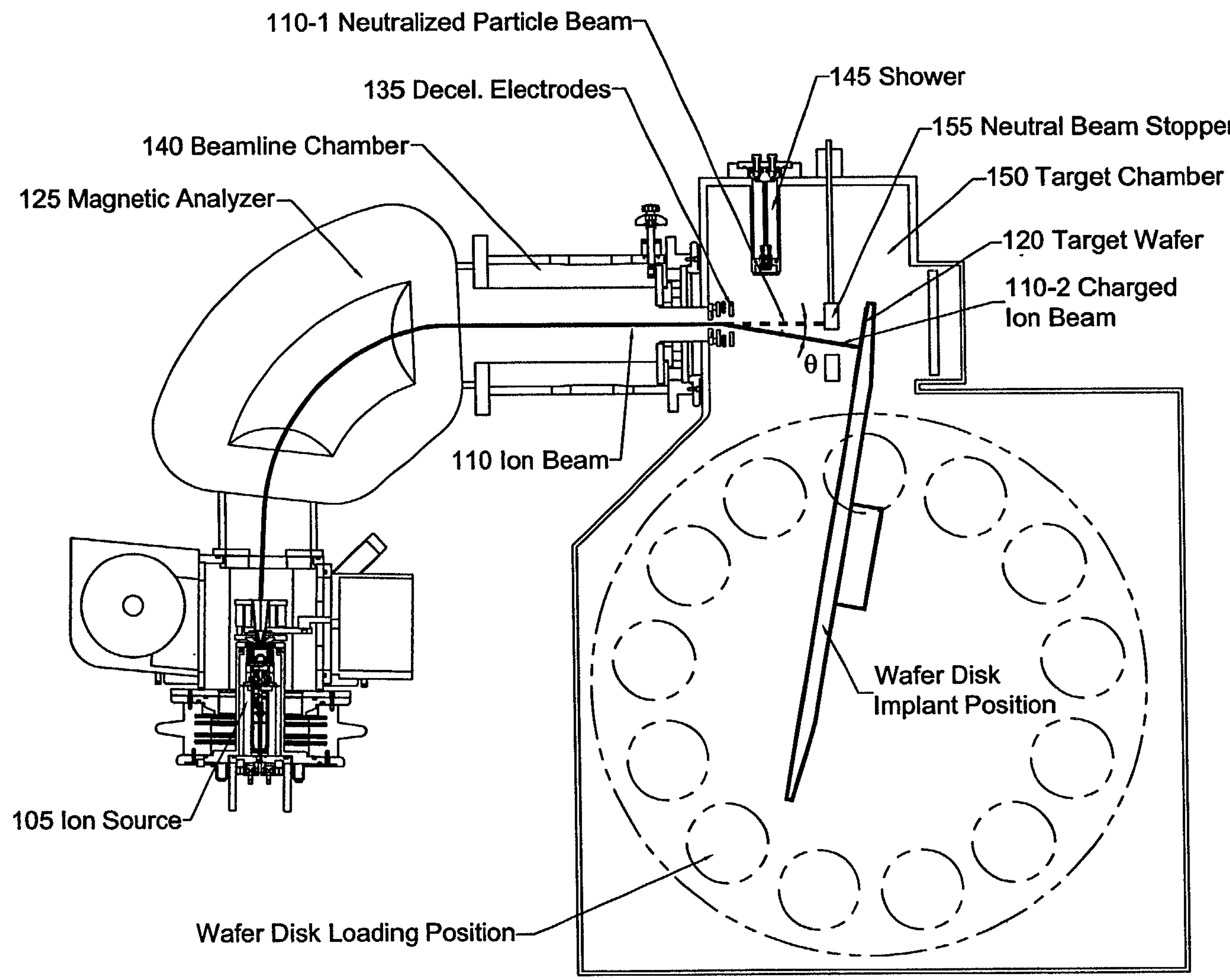
110-1 Neutralized Particle Beam
135 Decel. Electrodes
145 Shower
155 Neutral Beam Stopper
140 Beamline Chamber
150 Target Chamber
125 Magnetic Analyzer
120 Target Wafer
110-2 Charged Ion Beam
θ
110 Ion Beam
Wafer Disk Implant Position
105 Ion Source
Wafer Disk Loading Position

Figure 3a

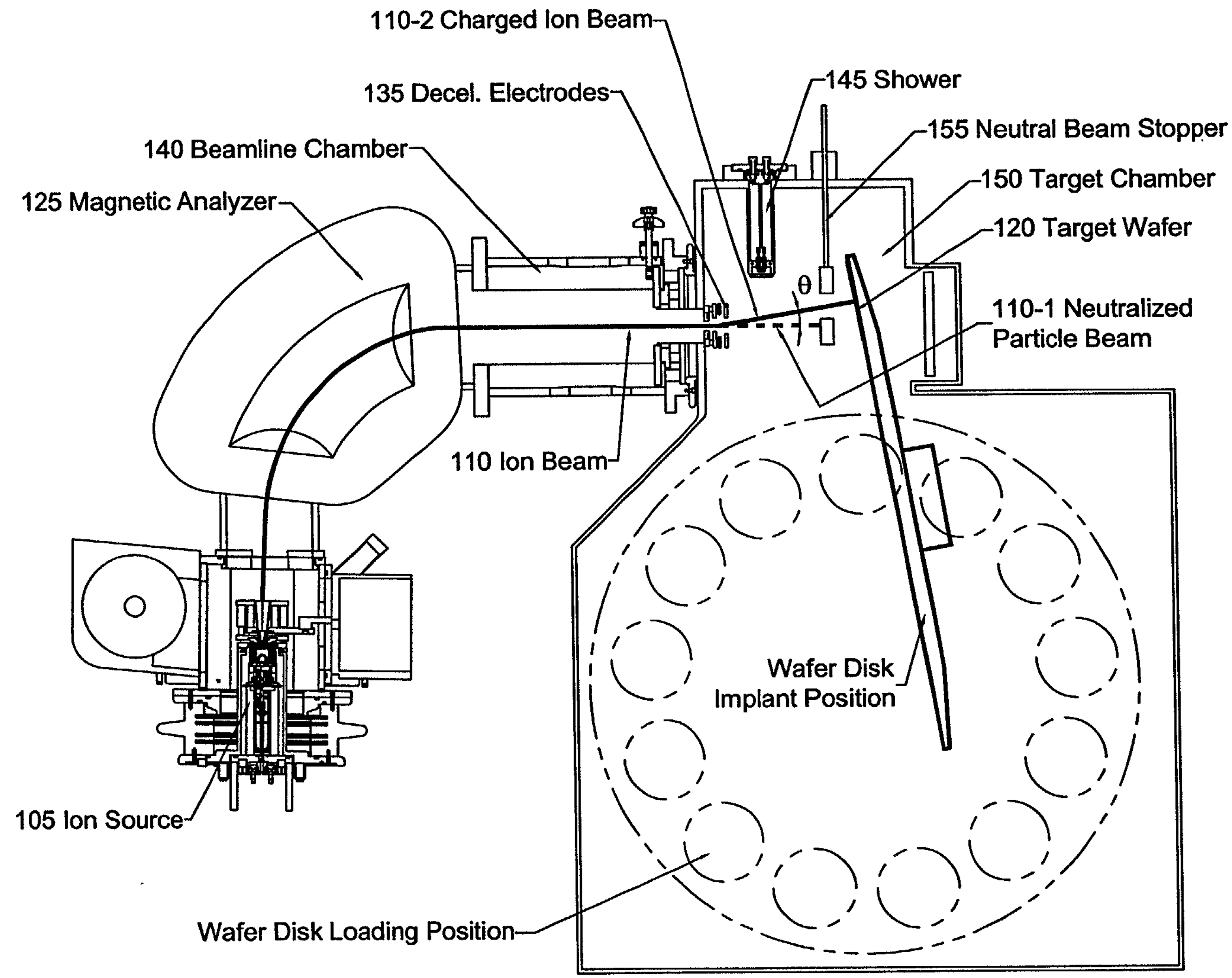
110-2 Charged Ion Beam
135 Decel. Electrodes
145 Shower
155 Neutral Beam Stopper
140 Beamline Chamber
150 Target Chamber
125 Magnetic Analyzer
120 Target Wafer
θ
110-1 Neutralized
Particle Beam
110 Ion Beam
Wafer Disk
Implant Position
105 Ion Source
Wafer Disk Loading Position

Figure 3b

Docket No. AIBT-9901

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

APPARATUS AND METHOD FOR REDUCING ENERGY CONTAMINATION OF LOW ENERGY ION BEAM

the specification of which (check one)

_X_ is attached hereto.

__ was filed on ________ as Application Serial No. ________ and was amended on ________

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s) Priority Claimed

(Number)	(Country)	(Day/Month/Year Filed)	__ Yes	__ No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

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Docket No. AIBT-9901

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Citizenship:

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Inventor's signature: Date:

Residence:

Citizenship:

Post office address: